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The Hessian Fly and Its Control by Late Sowing of Wheat in Oklahoma and Arkansas

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INTRODUCTION

The hessian fly is of considerable interest in Kansas, Oklahoma, and Arkansas because here the species is near the edge of its territory. In Kansas there is a rather indefinite western border line of injury, the species seldom occurring in large numbers in the western part of the State. There is also a southern limit, as the species is not commonly found in the Cotton Belt, even where wheat is grown, and its presence would not be expected in southern Arkansas. In Oklahoma both southern and western limits probably occur. Hence the hessian fly is not so regularly and seriously injurious in Oklahoma, Arkansas, and western Kansas as farther north and east. At times, however, it has shown capacity for injury to wheat in northern Arkansas and northeastern and north-central Oklahoma. This paper records information on the importance and control of the species in this area, in parts of which wheat is an important crop.

BIOLOGY

Here the species behaves much as in other infested areas. Active breeding occurs mostly in the spring and fall. Winter and summer are usually passed by mature larvae in the puparium, or "flaxseed." Moderate temperatures are required for activity, both cold and heat causing its cessation. Moisture is also needed; under very dry conditions activity is stopped or much restricted, whereas rainy weather is very favorable.

[1] Much of the work on the Oklahoma plots was done by the late J. S. Pinckney, at that time junior entomologist. Credit is also due several other members of the Bureau's station staff at Wichita, Kans., who assisted from time to time in obtaining data.

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When suitable weather sets in, many of the larvae that are inactive in the puparia become pupae, and within about 2 weeks the adults emerge. The adults are frail, gnatlike flies, about one-tenth of an inch in length. They live only a few days and are not known to feed. Mating quickly follows emergence, and eggs are usually laid within a day or so after emergence. These eggs are orange, about one-fiftieth inch long, and rather slender. They are usually laid in the furrows of the upper leaf surface. Larvae hatch within a few days and make their way down the leaves and inside the sheaths. Mortality is high during this process, especially under droughty conditions. When established, the larvae feed on the plant juices and grow rapidly. The newly hatched larvae are reddish, but on growing become white or greenish white. Growth is completed in a few weeks, the larva, if it has thriven, reaching a length of about one-fifth inch. When the larva is mature, the outer skin hardens and turns brown, and the larva inside shrinks away from the outer shell. Thus is formed the well-known puparium, or flaxseed. If conditions are favorable, many of the larvae in the flaxseed may pupate at once and give forth adults. If weather is unfavorable, all remain in the puparia, sometimes for long periods. Flaxseeds have been known to remain viable for several years and yield adults, though most of the larvae either die or become adults the first year.

In this area, as stated, there are usually two periods of activity—spring and fall. As a rule the spring period of favorable weather is long enough to allow two generations to develop. In the fall only one can usually develop between the end of summer and the advent of weather too cold for breeding. The flaxseeds that have passed the winter inside the sheaths of plants infested in the fall begin to yield flies late in March or early in April. Active development continues into early summer. Through the summer the only stage usually present is the flaxseed in the stubble. With the advent of cooler weather, usually in September, emergence of adults occurs and eggs are laid on whatever wheat is available. At this time of year emergence is often retarded by dryness. There are some irregularities in this cycle; there may be a little emergence and breeding in summer if conditions are unusually cool and moist. A favorable fall may extend the breeding season; emergence may be retarded by drought and take place unusually late after good rains. However, the outline given will usually hold pretty well. In the southern range of the species the long, hot summers undoubtedly reduce the numbers of the fly by desiccation of the puparia. Warm, dry winds when eggs are hatching also check the species.

INJURY

The hessian fly is best known for its attacks on wheat. It attacks barley also, sometimes seriously; rye is attacked, but usually very lightly. Wheatlike wild grasses are somewhat infested, though it seems doubtful if the populations thus developed are more than a small fraction of those on wheat. Oats are not attacked. There is considerable difference in the severity of attack on different varieties of wheat, but most varieties of commercial importance are severely attacked.

The larvae may in some cases reach large numbers, though at other times their numbers are insignificant. In the fall, on young wheat

plants, the effect of their feeding is marked. The infested shoots take on a characteristic dark shade and a dwarfed, thickened appearance. If the larvae are not too numerous, the infested plant may make up much of its loss by putting forth new tillers, but in many cases the vitality is severely depleted. The fall injury, if severe, may result in the death of plants. In the spring, early injury takes a similar form, but plants are then growing rapidly. A second type of injury later in spring is the weakening of the stems by larval feeding, causing lodging. In this region the same type of cool, moist season that favors a heavy second spring generation of the fly also favors heavy plant growth, lodging, and harvesting difficulties in wet fields.

CONTROL METHODS

Control measures are cultural in nature, and they include delayed fall sowing and the use of clean farming practices. Work is now being carried on at various experiment stations to develop new varieties that retain both fly resistance and characters desirable from other standpoints. This method shows great promise. Clean farming practices include such measures as turning under infested stubble before fall and surface cultivation to keep down volunteer wheat. These measures are of value where they can be employed. Keeping down volunteer wheat is especially desirable, since such wheat may be the source of large populations of the hessian fly. Volunteer wheat starting in August in wet seasons may harbor an early fall brood of the fly, which will mature and emerge before cold weather, to attack sown wheat.

Delayed sowing, however, has been the principal method for control of this insect. If there is little or no general fall infestation in or near the field, heavy spring infestation will not develop. The plan is to sow so late that before the wheat is up practically all hessian fly adults will have appeared and died. This has worked fairly well, though subject to several limitations. In some years fly activity in the fall continues unusually late. Very late sowing will result in small plants, often liable to winter injury, soil blowing, and reduced yield. This may be partly avoided by having a well-prepared and fertile seedbed so that wheat once up will grow rapidly. However, it has been found true that to sow late enough to miss all the fly infestation every year will result in serious winter injury in some years. The grower faces two probabilities—that of some fly infestation if he sows at a medium date, and that of some loss of yield from winter injury if he selects a later date. To select a compromise date or range of dates that will reduce the total risk as much as practicable is the aim of experiments in date of seeding. These experiments, of course, must be carried out separately in each area, and extensive work of this type has been done in most infested areas. It seems likely that further improvement could be secured by yearly observations which would consider the special conditions of each fall and enable entomologists to give growers information and recommendations suited to the particular year.

Date-of-seeding experiments are planned to give information on such questions as those just mentioned. In this area there are several peculiarities which raise other questions. As stated before, the hessian fly is near the edge of its territory and is less frequently

injurious than farther north and east. The winters are less severe, and winter injury to wheat is less common than farther north; very late sowing is often practiced with satisfactory yields. In Oklahoma winters are usually dry, and pasturing of winter wheat is often practiced. This is desirable from the standpoint of farm economy and diversification and is often followed by fairly good yields. It is more profitable where moderately early fall sowing can be practiced. Records of date-of-seeding experiments should be studied to determine to what extent general fly conditions permit this early sowing. Little or no information has heretofore been available on these general and special questions in Oklahoma and Arkansas.

To study these questions, work was conducted intermittently at several locations from 1916 to 1935. While these activities were subordinated to many others, considerable information has been gathered. The experimental seedings usually were made by cooperating farmers, and consisted in each case of several date plots sown side by side in a convenient place in the field. The dates were planned to be 5 to 7 in number, 5 days to a week apart, preceding and following the expected "fly-safe date." This plan was carried out with minor irregularities. While there was usually no plot replication in a given year and locality, the numerous years and localities constituted essential replication. In severe fly years the late and early plots showed differences greater than occurred from place to place in the field. Furthermore, the results agree in general with those of more elaborate experiments in plots at the laboratory, and with results in adjacent areas. Samples of fall infestation were taken late in the fall and samples of spring infestation and yield were taken at harvesttime. In most cases about 5 linear yards of row were taken from each plot for infestation, and 5 square yards for yield, 1 yard in each of five places in each plot. Some supplementary evidence in a locality was sometimes gathered by sampling fields.

The results may be studied for the evidence they give as to several questions. The lateness of sowing necessary to avoid all infestation, to avoid serious infestation, and to avoid serious infestation in most years are major questions. The effect of date of sowing on yield, as far as it can be detected, and the general level of fly infestation are also important.

In tables 1 and 2 are given (based on fall-infestation samples) the earliest sowing dates affording apparently complete freedom and comparative freedom (less than 5 percent of tillers infested) from fall infestation. These were estimated from a series of dates in each year. The expected safe date was estimated from work done in the United States in general (reported in Farmers' Bulletin 1627) or from experiments in the neighboring States of Kansas and Missouri. An estimate of the expected date follows the name of each locality in parenthesis. A dash indicates that no work was done in the locality; an "I" indicates that the date is indeterminate, as no infestation was found in samples from any plots. An asterisk indicates serious infestation in early plots, 20 percent or more of the tillers being found infested in some plots.

TABLE 1.—*Dates of earliest experimental wheat sowings found free or comparatively free from fall infestation by the hessian fly, Oklahoma, 1915–34* [1]

Autumn	Alva (Oct. 12)		El Reno, Kingfisher (Oct. 16)		Enid (Oct. 14)		Miami (Oct. 14)	
	Free	Below 5 percent	Free	Below 5 percent	Free	Below 5 percent	Free	Below 5 percent
1915	Sept. 25	Sept. 20						
1916			I	I				
1917								
1918								
1919					I	I		
1920	I	I	I	I	I	I	After Nov. 1	Nov. 1.
1921	I	I	I	I	I	I	Oct. 17	Sept. 26.
1922	I	I	I	I	I	I	Oct. 23	Oct. 16.
1923							Oct. 12	Oct. 12.
1924							*Oct. 16	Oct. 9.
1925							Oct. 2	Oct. 2.
1926	Oct. 10	Oct. 6					I	I.
1927	Oct. 17	Sept. 28			*Oct. 17	Oct. 12	Oct. 8	Sept. 28.
1928	I	I			I	I	*After Oct. 12	After Oct. 12.
1929	I	I			Oct. 15	Sept. 28	*After Oct. 15	After Oct. 15.
1930	I	I			Oct. 7	Sept. 27	Oct. 10	Sept. 27.
1931	I	I			Oct. 9	Sept. 28	After Oct. 16	Oct. 16.
1932	Oct. 4	Sept. 21			Oct. 5	Sept. 28	Oct. 11	Sept. 28.
1933							Oct. 7	Oct. 2.
1934							Oct. 5	Sept. 28.

Autumn	Muskogee, Wagoner (Oct. 18)		Newkirk, Ponca City (Oct. 13)		Tulsa (Oct. 16)		Vinita (Oct. 14)	
	Free	Below 5 percent	Free	Below 5 percent	Free	Below 5 percent	Free	Below 5 percent
1915								
1916			Oct. 4	Sept. 13				
1917								
1918	Oct. 12	Sept. 28	Oct. 14	Sept. 30			Oct. 7	Sept. 30
1919							*Oct. 22	Oct. 22
1920	Sept. 30	Sept. 21	Sept. 30	Sept. 24	Oct. 20	Oct. 5	Oct. 7	Sept. 30
1921	I	I	Oct. 16	Sept. 25	I	I	Oct. 17	Sept. 26
1922	I	I	Oct. 13	Sept. 26	Oct. 16	Oct. 10	Oct. 12	Oct. 8
1923	I	I	I	I	I	I		
1924			Oct. 16	Oct. 6	Oct. 9	Oct. 6		
1925					*Oct. 9	Oct. 6		
1926			*Oct. 14	Oct. 14	*Oct. 16	Oct. 16		
1927			*Oct. 17	Oct. 10	After Oct. 20	Oct. 16		
1928			Oct. 16	Oct. 11	Oct. 12	Oct. 4		
1929			Oct. 4	Sept. 30	After Oct. 15	Oct. 7		
1930			Oct. 8	Sept. 27	I	I		
1931			Oct. 16	Oct. 9				
1932			Oct. 5	Oct. 5	I	I		
1933								
1934								

[1] I indicates that the date is indeterminate; an asterisk (*) indicates serious infestation in early plots.

TABLE 2.—*Dates of earliest experimental wheat sowings found free or comparatively free from fall infestation by the hessian fly, Arkansas, 1916–27* [1]

Autumn	Fayetteville (Oct. 17)		Berryville (Oct. 16)		Marshall (Oct. 17)		Northeastern Arkansas [2] (Oct. 18)	
	Free	Below 5 percent	Free	Below 5 percent	Free	Below 5 percent	Free	Below 5 percent
1916	Oct. 16	Sept. 20			Oct. 30	Oct. 9	Oct. 16 (a) Oct. 17 (b)	Oct. 5 Sept. 18
1917	I	I			*Oct. 30	Oct. 23	I	I
1918	Oct. 18	Sept. 19			Oct. 1	Sept. 23		
1919	*Oct. 26	Oct. 26			*About Nov. 3	Nov. 3		
1920	Oct. 20	Sept. 25			Nov. 6	Oct. 14		
1921	I	I	Oct. 24	Sept. 26	Oct. 17	Sept. 26	I	I
1922	Oct. 27	Oct. 11	Oct. 16	Oct. 16	Nov. 1	Oct. 10	I	I
1923	Oct. 15	Oct. 15	I	I	Oct. 15	Oct. 15	I	I
1927					Oct. 6	Oct. 4		

[1] I indicates that the date is indeterminate; an asterisk (*) indicates serious infestation in early plots.
[2] In 1916 at Corning (a), also at Jonesboro (b); in 1917 at Jonesboro; in 1921, 1922, and 1923 at Batesville.

In tables 3 and 4 are brought together records to show further the levels of infestation. All are stated as percentages of culms infested. Records of infestation the preceding fall are averages for predate plots (before October 6 for Alva; before October 10 for Newkirk, Enid, and El Reno; before October 16 for Miami, Vinita, Tulsa, and Muskogee). Harvesttime records of spring infestation are averages of all plots, since small plots side by side all tend to become infested in the spring by flies emerging from the early plots.

TABLE 3.—*Percentages of wheat culms infested by the hessian fly in experimental sowings, Oklahoma, 1916–35*

Crop Year	Alva (Oct. 6) [1]		El Reno, Kingfisher (Oct. 10)		Enid (Oct. 10)		Miami (Oct. 16)		Muskogee, Wagoner (Oct. 16)		Newkirk, Ponca City (Oct. 10)		Tulsa (Oct. 16)		Vinita (Oct. 16)	
	Fall [2]	Spring [3]	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
1916	0.2	0.1														
1917			0	0							0.2	0.2				
1918																
1919									0.4	15.0	.1	.1			0.2	1.6
1920					0	0									13.7	4.8
1921	0	.1	0	0	0	1.3	6.9	20.1	.1	1.6	.1	0	0.1	0.6	.4	.1
1922	0	0	0	0	0	0	2.0	1.0	0	.1	.3	.2	0	14.4	17.2	2.9
1923	0	0	0	0	0	.1	5.2	22.8	0	.2	.2		4.6	13.3	1.6	13.2
1924							5.2	46.3	0	1.4	0	20.7	0	8.7		
1925							28.1	43.8			5.1	36.1	7.1	26.2		
1926							4.2	11.6					18.0	28.7		
1927	15.2	13.4					0	0			28.1	43.5	13.2	34.4		
1928	1.2	.5			31.3	7.5	1.2	4.3			19.7	5.1	10.3	1.8		
1929	0	.6			0	6.9	17.6	32.4			9.8	25.7	.6	3.1		
1930	0	.2			.6	.4	23.8	26.4			1.1	1.0	5.2	2.6		
1931	0	.2			2.0	6.4	.8	41.2			.3	.8	0	0		
1932	0	.8			1.5	2.0	9.0	24.2			4.0	1.6				
1933	1.7	.2			.3	.8	2.0	22.6			1.7	.3	0	.2		
1934							.8	3.4								
1935							.2									

[1] Dates in parentheses estimated from table 1, replacing dates from Farmers' Bulletin 1627.
[2] Fall, average of predate plots.
[3] Spring, average of all plots.

TABLE 4.—*Percentages of wheat culms infested by the hessian fly in experimental sowings, Arkansas, 1917–28*

Crop Year	Fayetteville (Oct. 16) [1]		Berryville (Oct. 16)		Marshall (Oct. 16)		Northeastern Arkansas	
	Fall [2]	Spring [3]	Fall	Spring	Fall	Spring	Fall	Spring
1917	2.8	0.1			6.4	3.3	(a) 2.0 (b) .5	0+
1918	0	.3			12.7	1.3	0	3.4
1919	4.6	6.6			0+	4.1		
1920	41.7	38.2			29.2	30.6		
1921	.7	.1			13.8	3.3		
1922	0	.3	0.8	0.6	1.6	1.2	0	.1
1923	1.3	1.1	11.4	2.7	2.8	.7	0	0
1924	0	2.0	0	5.3	0	1.7	0	.3
1928					.3			

[1] Dates in parentheses estimated from table 2, replacing dates from Farmers' Bulletin 1627.
[2] Fall, average of predate plots.
[3] Spring, average of all plots.

Northeastern Oklahoma, represented by Miami and nearby Vinita, is seen to be most regularly and seriously infested; 4 years out of 17 showed considerable infestation and all but one showed some (table 1). In 13 of the 17 years wheat sown October 16 was practically free of the fly, while in 2 years it was not. In 1929 and 1930 sowings were not late enough to test this date, but the last-sown plots showed a decrease. October 16 may be tentatively assigned as a practical safe date. At Tulsa, farther south in eastern Oklahoma, 12 years of work indicated somewhat less frequent injury and indicated the same date as safe. Still farther south, near Muskogee, very injurious numbers were not seen in 5 years of work, and results give no basis for a later date than at Tulsa and Miami.

In north-central Oklahoma, near Newkirk, occurrence was also regular and injury occasional; wheat sown October 10 was seldom much infested. Farther south and west in central Oklahoma, at Enid, El Reno, and Kingfisher, injury was less frequent and October 10 is again indicated as safe. In northwestern Oklahoma, at Alva, injury was indicated as very infrequent, and October 6 as usually safe.

In northwestern Arkansas, at Fayetteville and Berryville, as well as in north-central Arkansas at Marshall, occurrence of flies in plots was fairly regular, and injurious numbers were occasionally reached. October 16 seeding was safe from a practical standpoint in a majority of years. Results in some years suggest that in occasional mild, moist falls fly activity may persist very late and control by late seeding may be disappointing. In the lowlands of northeastern Arkansas infestation has been rare, and there is not much basis for assigning a date.

Sample yields have been examined for any effect of sowing dates that can be detected. In years of little or no fly infestation this influence should be apparent if it is strong, although, as stated, replication is only by years and localities. With heavy hessian fly infestations early seedings may be affected by fly injury and late seedings by winter injury; all seedings might be injured by spring infestation spreading into the small plots. The yields are grouped as follows: Those from

sowings within 3 days of the inferred safe date; the average of those from earlier sowings; the average from later sowings. These are presented in tables 5 and 6.

TABLE 5.—*Yields of wheat (bushels per acre) in Oklahoma plots, 1916–34*

Crop year	Alva (Oct. 6)			El Reno, Kingfisher (Oct. 10)			Enid (Oct. 10)			Miami (Oct. 16)		
	Predate	Safe date	Postdate	Predate	Safe date	Postdate	Predate	Safe date	Postdate	Predate	Safe date	Postdate
1916	18.5	20.4	14.9									
1917				27.0	38.9	35.6						
1918												
1919												
1920								31.3	3.4			
1921	34.8	26.0	18.7	20.2		22.0	16.6	12.5	14.6	18.3		16.0
1922	30.3	25.0	29.9				15.6	20.8		12.5	12.5	12.5
1923	16.1	29.2	24.4	8.3	12.5	12.0	22.4	12.5	8.5	6.6	4.2	6.2
1924										4.7	4.2	6.3
1925										[1] 4.2	4.2	
1926										24.2	19.8	
1927	24.0	32.3	27.6									
1928	40.2	35.2	39.5				[1] 23.6	23.7	22.2	18.8	19.8	
1929	20.1	25.3	28.6				11.0	10.9	10.4	[1] 8.6		
1930	31.6	30.2					8.4	8.8	9.4	[1] 13.2	7.3	
1931	21.2	24.0	19.8				15.6	15.6	15.6	14.8	18.8	
1932	22.9	21.4	16.7				19.3	19.0	19.3	12.5	12.5	
1933	3.6	2.3	2.3				13.8	15.2	13.1	28.8	32.3	
1934										18.4	22.9	
Average of comparable years	23.2	24.1	22.2				[2] 16.6	[2] 17.0	[2] 16.1	14.4	14.4	

Crop year	Muskogee, Wagoner (Oct. 16)			Newkirk, Ponca City (Oct. 10)			Tulsa (Oct. 16)			Vinita (Oct. 16)		
	Predate	Safe date	Postdate	Predate	Safe date	Postdate	Predate	Safe date	Postdate	Predate	Safe date	Postdate
1916												
1917				16.0	10.8	9.3						
1918												
1919				25.0	33.1	18.3				31.2	31.1	25.0
1920										[1] 16.6	11.5	12.2
1921	9.0		14.5	19.4		10.4	30.0	22.0	11.5	12.4	18.7	18.0
1922	20.5			10.4		5.2	5.4	8.3		25.2	16.0	16.2
1923	5.2	5.2	4.2				4.2	2.1	1.0	5.7	7.2	6.7
1924	13.5	8.3	8.3	23.0	30.2	29.0	22.8	27.0	15.1			
1925				9.0	9.4	6.2	7.2	5.0				
1926							[1] 20.0	19.8				
1927				[1] 3.1	7.3	6.3	[1] 8.1	11.5				
1928				[1] 11.5	9.6	12.5						
1929				13.0	14.6	12.5	17.0	15.1				
1930							9.9	13.5				
1931				15.1	14.5	14.6	14.1	16.7				
1932				14.8	10.4	10.9						
1933							4.3	4.7				
1934												
Average of comparable years	9.2		9.0	14.5	15.5	13.3	13.0	13.2		18.2	16.9	15.6

[1] Considerable fly infestation, 20 percent or more in worst infested plot.
[2] Includes El Reno and Kingfisher.

TABLE 6.—*Yields of wheat (bushels per acre) in Arkansas plots, 1917–28*

Crop year	Fayetteville			Berryville			Marshall		
	Pre-date	Safe date	Post-date	Pre-date	Safe date	Post-date	Pre-date	Safe date	Post-date
1917	21.9	16.9	15.4				44.7	42.6	38.8
1918	24.4	22.5	25.4				15.5	16.1	16.6
1919	14.1	10.0	6.9				[1] 8.3	2.5	8.3
1920	[1] 10.4	11.4	15.2				22.4	25.0	25.0
1921	(2)	(2)	(2)				[1] 16.2	16.2	16.2
1922	(2)	(2)	(2)	(2)	(2)	(2)	16.5	12.5	
1923	(2)	(2)	(2)	(2)	(2)	(2)	8.3	9.4	5.8
1924		16.7	11.8	19.8	15.6	16.6		11.5	7.6
1926									
1927									
1928							(3)	(3)	(3)
Average of comparable cases	[4] 18.1	[4] 15.3	[4] 15.9				16.5	16.0	15.8

[1] Considerable fly infestation, 20 percent or more in worst infested plot.
[2] Not comparable.
[3] All winter-killed.
[4] Includes Berryville.

DISCUSSION AND CONCLUSIONS

Owing to the infrequent occurrence of serious infestations and the limited amount of data from points in this wide territory, the establishment of safe sowing dates is difficult. However, those indicated in tables 3 and 4 were satisfactory in most years of noticeable infestation. Although the nature of the data makes critical statistical analysis difficult, it is believed that the figures presented in the tables make possible some tentative conclusions.

First to be noted is the conclusion that the hessian fly in this territory is not usually a major problem. In places on the edges of the area, such as Alva on the west, Enid, El Reno, and Kingfisher on the southern border of the range in central Oklahoma, Muskogee in southeastern Oklahoma, and the low-altitude stations in eastern Arkansas, occurrence of the fly in any numbers has been very infrequent. In the Ponca City-Newkirk area in north-central Oklahoma, at Miami and Tulsa in northeastern Oklahoma, and at the Ozark stations (Fayetteville, Berryville, and Marshall) occurrence has been more regular, with an occasional rise to considerable numbers. Miami was most consistently infested; conditions there are more like those of eastern soft-wheat areas than at the other places. Even at these points it is difficult to infer from plot yields that the fly is very important in crop reduction.

Second, the fall infestation records give the general impression that the safe-sowing dates based on extension of the lines of Farmers' Bulletin 1627 hold pretty well. Sowing following these dates should give a high probability of practical freedom from infestation. Records give a hint that as the southern border is approached the safe dates do not run consistently later. There is little reason for later sowing at Tulsa than farther north, at Miami, or for later sowing at Enid than at Ponca City.

Third, there is little evidence of consistent reduction of yield from delaying the sowing until the safe date. In some years later sowings outyielded earlier ones; in other years the earlier ones gave higher

yields. Extremely early sowing in this region might carry a risk of heat damage to young plants. The records from some of the stations indicate some decrease in yield associated with very late seedings.

At the points indicated as on the border of the area of the injury (Alva; Enid, etc.; Muskogee; and northeastern Arkansas) the delaying of wheat seeding until the safe date in order to avoid hessian fly damage would not ordinarily appear to be justified. In northeastern Arkansas and southeastern Oklahoma there is very little wheat, but territory represented by Alva and Enid is important in wheat production. If a harvesttime or summer survey could be made annually and timely warnings could be issued in those exceptional years when fall infestation appears imminent, the observance of the safe dates by the farmers in making their sowings could well be limited to these exceptional years. In the Ozarks, northeastern Oklahoma, and north-central Oklahoma safe dates may well be observed. Precaution could be relaxed in years when the surveys show only light infestation, especially where pasturing is important.

It seems inadvisable to sow wheat extremely early (in early or middle September) anywhere in this area. Such wheat might be injured by heat or by insects other than the hessian fly. Observations on infestation in volunteer wheat show that extremely early sowing on a large scale would tend to build up hessian fly populations. Sowing very late (November 1 or later) would seem to carry considerable risk of reduced yields.

Safe dates are suggested by the tables as follows: Alva, October 6; Ponca City, Enid, etc., October 10; Miami, Tulsa, Muskogee, and Arkansas Ozark points, October 16. In northeastern Arkansas the evidence is insufficient to suggest a date. These dates are believed to give a high probability of practical freedom from fly infestation and a low probability of winter injury. It is suggested that they be observed in the more regularly infested localities except in years of known light infestation; and in the less frequently infested regions only in years when surveys show substantial infestation.

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